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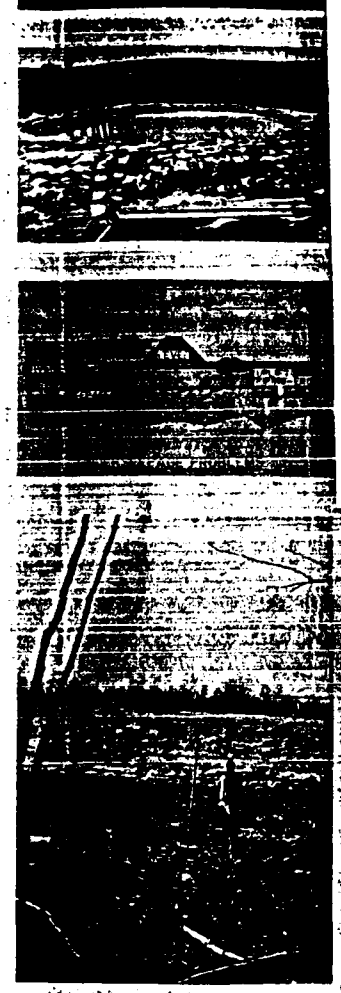
TECHNICAL REPORT REMR-GT-5

INSPECTION AND CONTROL OF LEVEE UNDERSEEPAGE DURING FLOOD FIGHTS



by

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September 1987
Final Report

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This study was conducted in response to a problem definition workshop held in April 1984 for the Repair, Evaluation, Maintenance, and Rehabilitation (REMR) Research Program, Work Unit No. 32274, "Rehabilitation Alternatives to Control Adverse Effects of Levee Underseepage." The following research need was determined to have one of the highest priorities: Emergency flood fight guidance for observing underseepage and employing remedial actions.

Documented in this report are the basic levee inspection responsibilities and flood fighting techniques of the Mississippi River Valley Districts (Rock Island, St. Louis, Memphis, and Vicksburg) and the Levee Boards. The need for a consistent terminology for the severity of underseepage, better flood fight training for young engineers, and better mobility for inspection were the main problems identified in this report.

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The following terminology is recommended as a standard to describe the severity of underseepage:

Light - area is wet.

Moderate - running water is observed.

Heavy - pin boils (small pipe openings without sand cones) with running water.

Sand boils - any pipe opening with sand cones.

Large boils - sand boils with pipe openings 12 inches or more in diameter (size described by diameter of pipe opening).

Personnel interviewed, documents collected from CE District offices, and a list of questions related to inspection for underseepage during floods are included in Appendices A, B, and C, respectively.

PREFACE

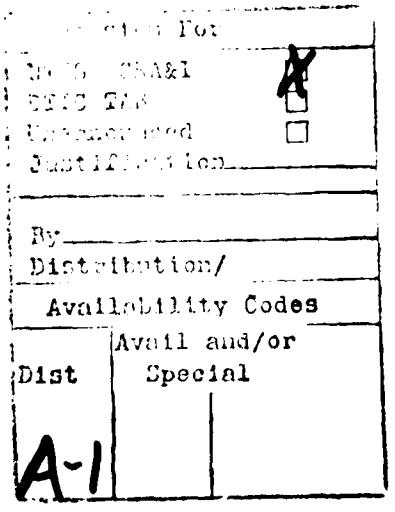
The study reported herein was performed under Contract/Purchase Order No. DACW39-85-M-3154 during the period 1 June 1985 through 31 August 1985, as a research need of the Civil Works Work Unit 32274, "Rehabilitation Alternatives to Control Adverse Effects of Levee Underseepage," of the Repair, Evaluation, Maintenance, and Rehabilitation (REMR) Research Program being conducted by the US Army Engineer Waterways Experiment Station (WES).

This report was prepared by Mr. Robert W. Cunny. The study addresses the inspection, evaluation, and flood fighting techniques of the Mississippi River Valley Districts, i.e., Rock Island, St. Louis, Memphis, and Vicksburg. This report is a digest of the information collected and includes recommended guidance for evaluation of levee underseepage and remedial measures to be used during a flood fight. The cooperation of many individuals from District, Division, and site offices is gratefully acknowledged and appreciated by WES.

The study was under the direct supervision of Mr. G. B. Mitchell, the Problem Area Leader, Soils Mechanics Division (SMD), Geotechnical Laboratory (GL). Messrs. S. P. Miller, E. V. Edris, Jr., and H. M. Taylor, Jr., were Principal Investigators during the conduct and publication of the work. General supervision was provided by Mr. C. L. McAnear, Chief, SMD, and Dr. W. F. Marcuson III, Chief, GL.

The Directorate of Research and Development Coordinator for REMR in OCE was Mr. Jesse A. Pfeiffer, Jr., and members of the REMR Overview Committee in OCE were Messrs. John R. Mikel and Bruce L. McCartney, and Dr. Tony C. Liu. The WES REMR Program Manager was Mr. William F. McCleese.

COL Dwayne G. Lee, CE, was Commander and Director of WES. Dr. Robert W. Whalin was Technical Director.



CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC)
UNITS OF MEASUREMENTS

Non-SI units of measurement can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
acres	4,046.873	square metres
feet	0.3048	metres
inches	25.4	millimetres
miles (US statute)	1.609347	kilometres
square miles	2.589998	square kilometres

INSPECTION AND CONTROL OF LEVEE UNDERSEEPAGE DURING FLOOD FIGHTS

PART I: INTRODUCTION

Background and Purpose

1. A Repair, Evaluation, Maintenance and Rehabilitation (REMR) Levee Underseepage Workshop* was held at the USAE Waterways Experiment Station, Vicksburg, Mississippi on 19 April 1984 to establish research needs for control of levee underseepage. Representatives from the Vicksburg, Memphis, St. Louis, and Rock Island Corps of Engineer (CE) Districts attended this meeting. One of the tasks established involved: (a) the development of guidance for the evaluation of levee underseepage and remedial measures for control of levee underseepage, and (b) remedial measures that can be used to control levee underseepage during a flood fight on a short-term basis. At that time, an investigation was authorized and then contracted to provide the desired information.

Scope

2. The investigation included visits to the Vicksburg, Memphis, St. Louis, and Rock Island CE Districts to collect written data and conduct interviews with personnel experienced with levee underseepage. Personnel visited in each of the District offices are listed in Appendix A. Written data collected is listed in Appendix B and has been furnished to the Contracting Officer's Representative. Prior to the visit to the District offices a list of questions was prepared and then used during the visit to collect information from those interviewed. This list of questions is included as Appendix C. This report is a digest of the information collected and includes recommended guidance for evaluation of levee underseepage and remedial measures to be used during a flood fight.

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* The results of the workshop will be documented in the final report for the Work Unit 32 274, "Rehabilitation Alternatives to Control Adverse Effects of Levee Underseepage," in September 1987.

General Information about Corps of Engineer Districts Visited

3. Since the size (square miles) of the CE District, miles of levee, and number of personnel might influence the way different CE Districts respond to their flood fight responsibilities, this type of information has been obtained. Of the four CE Districts visited Rock Island is the largest at 78,300 square miles and Memphis the smallest at 25,000 square miles. Vicksburg has 1760 total miles of levee which is more than the other CE Districts, but each of the other CE Districts has more miles of mainline Mississippi River levee (about 600 miles versus 451 miles for the Vicksburg District).

4. Vicksburg has a total of about 1400 personnel which is the largest, versus Memphis with about 550 which is the smallest among the four CE Districts. Vicksburg has the largest Foundation and Materials (F & M) Branch with 72 people of which 28 are professionals. Rock Island has the smallest F & M (Geotechnical) Branch with 11 people of which 6 are professionals.

5. The responsibility of each CE District office as it is related to underseepage control and as it impacts on F & M Branch personnel is stated in ER 500-1-1, paragraph 2-4c(9), and is quoted here in part:

> "Provides technical assistance by advising non-federal interests in their efforts to maintain the integrity of flood control works .... When non-federal interests have committed their resources, and are unable to cope with flood ... situation, directs Corps assistance either by supply of needed materials and equipment, or by undertaking Corps flood fighting and rescue operations."

PART II: LEVEE DISTRICT AND BOARD ACTIVITIES

Organization and Responsibility

6. Levee Districts along with Drainage Districts, city organizations, or other legally constituted governing bodies are the sponsors for the levee projects and thus are responsible for the maintenance of the levees. Levee Districts vary in size and in the performance of their inspection and maintenance responsibilities. Each Levee District is governed by a Levee Board that is made up of local landowners and civic leaders, some of whom are either elected or appointed, and some of whom are ex-officio members. Some of the larger Levee Districts have permanent staffs, which consist of office workers, maintenance workers, and at times even an attorney and/or an engineer.

7. Ordinarily the Levee Board members are conscientious and very much concerned about the status of their levee. The Board members commonly patrol their levee periodically throughout the year and are well aware of past trouble spots. As a flood season approaches and the river becomes bank full, the activities of the Board members increase, and the members or their representatives can be expected to be inspecting the levee on a daily basis. However, in some of the smaller rural Levee Districts and in some urban areas, the activities of the Levee Boards are less than satisfactory; in some cases, maintenance deficiencies have accumulated without adequate remedy.

Levee Inspection by Levee Boards

8. The inspection teams from the Levee Boards vary and can consist of a Board member, a maintenance foreman, and/or an experienced maintenance worker. The inspections are normally from the cab of a truck on the crown of the levee, but the inspectors will get out and go down to trouble spots at the toe or beyond; these trouble spots are sometimes flagged so that they will be easily spotted on subsequent inspections. All Levee Districts are invited to send representatives to Flood Fight Seminars held annually by CE District offices, but the Levee District inspectors may or may not have had the benefit of such training. These inspectors generally have experience from past flood fights, and they either know or have been told where past trouble spots are located. At relatively low flood stage, the inspections might be made every

couple of days, but as the flood stages get higher, the inspections get more frequent until they are sometimes done once or even twice a day. There are no requirements for written reports from the Levee District inspectors; it is strongly recommended that this valuable levee performance data be entered in the appropriate flood fight report. Written guidance for evaluation of underseepage is available in CE pocket size handbooks* on a liberal basis to anyone involved in flood fight activities. These handbooks have different titles in different CE offices, but the titles are similar such as Flood Emergency Handbook or Emergency Flood Control Activities.

Emergency Treatment of Underseepage Problems

9. There is no standard terminology to describe the severity of levee underseepage, but when the Levee District inspector finds what appears to be levee threatening seepage, he will call in a senior member of the Levee Board or a CE liaison representative to make an evaluation. Written guidance available for evaluation of sand boils included in the Memphis District Handbook is quoted in part:

> "...Any boil which enlarges and increases its discharge of material, especially if located within 200 ft of the levee toe, is considered to be a threat to the levee and should be controlled.... Boils running clear water, unless they have an excessive amount of discharge, may need no treatment except to be watched and to ditch the water away from the levee.
>
> (1) The treatment of sand boils consists of building a sandbag loop... to raise the water level...to a height sufficient to stop or minimize the discharge of material...Warning: No boil should be sacked high enough to completely shut off the water....
>
> (4) If, at any time, sand boils either inside or outside protection loops show signs of discharging with increasing force,... the Area or Section Commander must be promptly notified...."

The handbook guidance includes descriptions of where and how the sandbags should be placed, as well as drawings to show details of the sandbag loops.

10. On some occasions Levee District personnel will begin sandbag operations without consultation with CE personnel. In this case, the sandbagging

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* Appendix B: Documents collected from CE Districts Offices cite available guidance for evaluation of underseepage.

will be done with supplies and material provided by the Levee District and largely volunteer labor. Alternatively, if the seepage control activity exceeds the capabilities of the Levee District, they may formally so notify the CE District Commander, and the CE will supply material and, if necessary, labor to accomplish the work. This assistance is provided by the CE under the provisions of PL 84-99 for flood fighting operations.

PART III: AREA ENGINEER ACTIVITIES

Relationships with Emergency Operations Center

11. Each of the CE District offices has an Emergency Operations Center (EOC). The Emergency Operations Manager (EOM) and/or the Natural Disaster Program Manager serves as the primary CE District point-of-contact for all flood emergency operations; all field forces assigned to actual flood fight duty (excluding Engineering Division personnel engaged in obtaining flood damage and engineering data) operate directly under the EOM. The CE District is divided into Areas, Sectors, and where appropriate, Subsectors. Prior to an emergency situation, CE District personnel will have been preassigned to positions of Area Commander or Engineer, Sector Commander, Deputy Commander, and other appropriate positions. In Vicksburg, St. Louis and Rock Island Districts, all F & M Branch personnel are exempt from preassignment by the EOM so that they may collect engineering data or be available to respond to requests for technical assistance anywhere in the District. This exemption should also apply to certain Operations Division personnel since Operations Division is responsible as the primary contact between the Corps of Engineers and the Sponsors of the local Corps built flood control projects and could be required to perform duties at locations other than that preassigned by the Emergency Operations Manager.

Area Engineer Surveillance and Liaison

12. The development of a full flood fight usually involves at least two phases. Phase I begins when the river stage reaches a predetermined level (generally about bank full or somewhat greater) and higher stages are anticipated. The EOM puts the flood fight organization into mobilization status, and area engineer offices are opened if they are not already in operation. The Area Commander makes contact with Levee Board personnel to be sure that local interests are on the job and aware of the developing flood situation. The Area Commander also activates levee patrols which establish and maintain close liaison with federal and non-federal interests (Levee Boards, etc.) and report field conditions to the Area Commander who in turn reports to the EOM on a daily basis.

13. Phase II of the flood fight becomes established when the river rises to a stage where significant problems have occurred in the past. This stage is preestablished in the emergency operations plan for each of the various reaches of the river. During Phase II the Area Commander staff is augmented with additional personnel from the EOM's preassignment list. Sector offices are opened, patrols are made on a daily basis, and a situation report is submitted through the Area Commander to the EOM each morning. A situation report is in turn provided from the District office to the Division and to the Office of the Chief of Engineers (OCE).

14. During a Phase II situation, Sector Commanders and/or members of that staff patrol the levee. Technically these people are not inspectors, but are CE liaison representatives who keep the EOC and therefore the CE District Commander informed of the field situation. They commonly will patrol the levee with the Levee Board inspectors, and when trouble spots are sighted, they might jointly decide what should be done.

15. Personnel from the Sector office commonly are experienced in flood fight activities. Sector Commanders and deputies normally are engineers, and other staff members generally are senior technicians, construction representatives, or the equivalent. If they are new to the position, they will accompany experienced personnel on their first inspection trip. No formal underseepage training is required for these representatives, but more than likely they will attend briefings concerning underseepage problem identification which are conducted by experienced personnel. One instruction to new personnel would likely be to report all wet areas. No special terminology is used to describe underseepage trouble spots, but when areas with flowing water or sand boils with muddy water are observed, they are reported to the Sector Commander and in turn to other senior staff members.

Emergency Treatment of Underseepage Problems

16. When a dangerous looking area is reported, the EOM can ask for geotechnical assistance from the F & M Branch to inspect and advise the EOC as to what should be done to provide the necessary protection. The geotechnical representative makes his recommendations to the EOC which in turn notifies the Levee District. If the Levee District has the resources, it will do the work.

If they do not have the necessary resources, they will write the CE District Commander who will then undertake the work with his staff and resources.

17. The routine technique for controlling sand boils is the sandbag loop. Guidance for building the sandbag loop is contained in the pocket size handbook mentioned earlier. If a number of boils close together require treatment, a sack sublevee should be built around the entire group of boils, rising to a height necessary to control the most serious boils.

18. Expedient techniques used with varying degrees of success to control boils include the following:

a. Corrugated metal pipe or barrels with ends removed can be placed over the boil with a savings of labor and sandbags. However, the ground around the boil has to be relatively firm or water will flow from around the outside of the pipe.

b. Filter cloth weighted with stone and/or gravel may be placed over an extended area with general seepage. As with other methods, seepage may escape from beyond the edge of the filter cloth if conditions are not favorable.

c. Concrete aggregate and stone can be dumped in the boil throat to reduce seepage and loss of material.

d. Existing nearby deep wells may be pumped to reduce the pressure in the pervious substratum.

PART IV: FOUNDATION AND MATERIALS (GEOTECHNICAL) BRANCH ACTIVITIES

Responsibilities during Flood

19. The Foundation and Materials (F & M) Branches in all CE District offices provide technical support to the EOM during a flood fight as provided in ER 500-1-1, Natural Disaster Procedures. In Vicksburg, St. Louis and Rock Island Districts all F & M Branch personnel are exempt from special assignment by EOM, so that this technical support may be provided and geotechnical engineering data may be collected.

Special Activities

20. During or near the crest of the 1973 flood, the Vicksburg District F & M Branch personnel (in four-man teams) walked the toe of some 375 miles of mainline levee, photographed and documented all underseepage trouble spots by levee station, and superimposed seepage observations on topographical and geologic quadrangle maps. During subsequent floods, F & M personnel inspected the mainline levee for underseepage and compared the observations with those documented in the 1973 inspection report.

21. In the St. Louis District, the Emergency Operations Plan provides that the Chief of the F & M Branch shall:

a. Dispatch technical personnel to monitor piezometers and relief well flows.

b. Dispatch geotechnical engineers to the field to visually evaluate embankment performance and seepage conditions, and expedite evaluation of piezometer and well data.

22. In the Rock Island District, teams from the Geotechnical Branch patrol the levee and document all observed underseepage distress when the river is near crest conditions. This information is put on plan maps stored in permanent files. These maps are then used in subsequent flood seasons so that areas with a history of problems can be closely monitored, and current performance compared with that of the past.

23. Technically, inspection conducted by F & M Branch and other CE personnel should be called surveillance, since inspection is the official responsibility of the Levee Districts. However, regardless of what the CE activity

is called, it is important that CE activity include backup performance observations so that a developing serious problem is not overlooked by those with possibly less experience.

24. Inspection teams from the F & M Branch normally involve two or more members, and a large portion of the inspection involves walking along the toe of the levee, or riding a three-wheel all-terrain vehicle along the toe of the levee if such is available. Inspections are made as frequently as possible, but they normally are less than daily due to the limited number of F & M Branch personnel. These personnel are normally not given special training for underseepage inspection since they are considered qualified by education and experience; however briefings are conducted by senior staff members when appropriate, and new employees will initially be accompanied by experienced employees at least for the first couple of days. F & M Branch inspection teams are not required to make daily written reports as are Sector Commanders, but if an unattended levee threatening problem area was observed, this would be reported verbally. F & M Branch teams document their observations for their permanent data files as soon after the inspection as possible.

25. No standardized terminology is used from one District to the next to describe the severity of underseepage. Although any one inspector probably has a more or less consistent set of terms that are used, it would be desirable to establish a uniform system so that performance from different areas might be compared on a more or less uniform qualitative basis. Terminology for such a system is suggested in the recommendations of this report.

26. Evaluation of the seriousness of observed underseepage is another problem. Written guidance available in the flood control handbooks helps, but there are some things like the effect of the type of the top stratum, the extent of the seepage, and the geology of the area that cannot be incorporated in a handbook; therefore, the evaluation of the underseepage and the final recommendation as to what should be done to control the seepage should be made by an experienced geotechnical engineer. In practice, this is what generally happens in the field. When inspectors observe what appears to be troublesome underseepage, they report it to the EOM. Assistance is requested from the F & M Branch, and the chief of the Branch and the EOM, and on occasion the District Commander, will go to the site, make their inspection, and determine what should be done. This type of inspection trip for senior staff personnel is commonly made in a helicopter; this type of transportation provides not

only the most rapid access to the site in question but also a very good view of the underseepage condition for long reaches of levee in a very short period of time. It also permits the viewing of conditions landward of the levee toe that sometimes cannot be seen from the crown of the levee or when walking the toe of the levee.

Concerns of the F & M Branch Chiefs

27. Some of the issues raised in interviews with F & M Branch chiefs focus on technical issues, and others relate to local policy and management decisions. All are reported here.

28. In the Memphis District where the geotechnical engineers are pre-assigned by the EOC, the engineers are sometimes sent to areas or sectors where the geotechnical problems are not particularly great. This situation would be improved if the chief of the F & M Branch had some say as to where the geotechnical engineers are assigned.

29. More than one of the F & M Branch chiefs suggested that a classification system for describing the severity of underseepage is needed. In addition a training film is needed that will show the different degrees of severity of underseepage, the effect of sand boils on levees, and the effect of geology on the intensity of underseepage. The training film could be used for Levee Board and CE personnel and might also be used to educate the public to prevent undue concern over moderate underseepage.

30. Several CE District personnel highly praised the use of all-terrain vehicles during inspection in the vicinity of the levee toe and suggested that their availability be assured for inspections during flood fights.

31. In the St. Louis District, local interests are responsible for maintenance of relief wells. ER 1110-2-100* calls for the wells to be inspected a minimum of every fifth year. It is very difficult to force local interests to perform relief well maintenance. It is estimated that as many as 50 percent of the relief wells in urban areas may have major dysfunctions. It was suggested that the F & M Branch be funded for inspection and pumping of wells, at least in urban areas, much in the same way and for the same reasons

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* Department of the Army, US Army Corps of Engineers, "Engineering and Design: Periodic Inspection and Continuing Evaluation of Completed Civil Works Structures," ER 1110-2-100, 28 February 1983, Washington, DC 20314.

that the Mechanical Section in the Engineering Division is funded for inspection of pumping stations. Similar funding and responsibility should be assigned to the F & M Branch for piezometer maintenance, which is a District responsibility. Then funding for maintenance would be placed in the same organization that performs analysis and design.

Other Concerns

32. Other comments were heard during the interviews conducted. While they are considered beyond the scope of this study, they are included here for information. In the St. Louis District where there are many relief wells, training of young engineers for prompt field evaluation of underseepage is a problem. New personnel need experience in both underseepage analyses and underseepage control methods and techniques. Also the limited number of new Corps projects that require underseepage design limit the "hands on" training opportunities for new employees; however innovative training techniques may overcome this deficiency.

33. At the completion of a flood fight, two types of evaluation should be made:

a. Technical to include documentation of visual observations made and an analysis of piezometer and relief well data collected.

b. Operational to include a record of the response of local interests to CE advice and an assessment of maintenance practices on the performance of flood control structures.

Funding for these reports is generally not available, but documentation of such information is invaluable for the next major flood emergency.

34. New CE policy requires that all levees that have been rehabilitated under Public Law 84-99 be inspected to determine adequacy of local maintenance. If deficiencies have not been corrected in two years after formal written notice, local interests are advised that they are no longer on the inspection schedule, are no longer eligible for Public Law 84-99 funds for rehabilitation of levees, and will not be eligible until deficiencies have been corrected. Refer to ER 500-1-1, page 5-2.

35. Based on analysis* of permeability ratios from LMVD and Rock Island

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* Cunny, Robert W. 1980. "Documentation and Analysis of Rock Island Underseepage Data," Technical Report GL 80-3, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

levee performance data, suggested LMVD design permeability ratios of 1000 to 400 appear to be too high for other District's geologic setting. Design procedures are not adequate for predicting the hydraulic head at the levee toe when the levee bends at less than 180 deg. Design procedures do not adequately treat three-layer systems; for example, high heads occur in silty sand under a top stratum even though large flows come from well screens in deeper medium to fine sands.

36. Rock Island District personnel raised questions about inadequate design criteria for strengthening or enlarging levees, but the subject was not pursued as it was agreed that it was beyond the scope of this effort.

PART V: CONCLUSIONS AND RECOMMENDATIONS

Technical and Operational

37. A standardized terminology for severity of underseepage should be adopted. The following is recommended:

Light - area wet at and beyond levee toe.

Moderate - running water is observed at and beyond levee toe.

Heavy - pin boils (small pipe openings without sand cones) with running water.

Sand boils - any pipe openings with sand cones.

Large boils - sand boils with pipe openings 12 in. or more in diameter (size described by diameter of pipe opening).

For each of the above categories, the condition of the running water should be described: clear, muddy, carrying sand, etc.

Policy and Management

38. The following recommendations were offered by those interviewed concerning interfaces between Engineering and Operations. While each Field Operating Agency (FOA) has considerable autonomy in how it structures itself for a flood fight, the insights offered by those interviewed indicate that in some cases more technical expertise could be brought to bear through greater F & M Branch involvement.

39. A training film showing the different degrees of severity of underseepage should be prepared. The film should provide guidance as to when protective action should be taken and should show the various types of remedial treatment that might be used.

40. All-terrain vehicles should be made available to F & M Branch personnel upon request. This transportation will permit more efficient and more rapid underseepage inspection near and landward of the levee toe.

41. Helicopters should be used for underseepage inspection on occasion because they permit rapid viewing of potentially critical areas landward of the levee toe that might not be seen during regular inspections.

42. Evaluation of levee underseepage should be made by trained geotechnical engineers considering factors presented in the flood fight handbooks and

quoted in part in paragraph 9 of this report. Sandbag loops are the most common and most reliable structure for control of underseepage. Other techniques listed in paragraph 18 can be used as the occasion may warrant.

43. District F & M Branch personnel should be funded in some way so that they can participate in the inspection and maintenance of the District piezometers.

44. Strong enforcement action should be taken by the Districts so that local interests maintain relief wells to ensure they function properly during a flood.

45. District F & M Branch personnel should either be exempt from the EOM's preassignment list for flood fight duty or if assigned, be assigned to sectors which have historically had seepage problems. This assignment would permit them to document underseepage performance and be available to respond to requests for technical assistance anywhere in the District.

46. It is recommended that efforts are made to ensure valuable levee performance data (design information) collected during high-water events by the levee boards is entered in the flood fight report for a District.

APPENDIX A: PERSONNEL INTERVIEWED

1. This investigation included visits to the Vicksburg, Memphis, St. Louis, and Rock Island CE Districts to collect written data and conduct interviews with personnel experienced with levee underseepage. Personnel interviewed, their position title, and organization follows:

a. At Vicksburg District:

(1) Robert L. Fleming, Chief, F & M Branch

(2) John A. Ashley, Natural Disaster Manager

(3) T. Wayne Forrest, Engineer, F & M Branch

(4) John W. Scroggins, Technician, F & M Branch

(5) Cooper Trevilion, Contractor's Representative, Vidalia Field Office.

(6) Charles H. Caldwell, Operations Division

b. At Memphis District:

(1) Joe Keithley, Chief, Geotechnical Engineering and Survey Branch

(2) John Monroe, Chief, Geotechnical Design Section

(3) Ron Dunn, Chief, Levee and Drainage Section

(4) Ken Williams, Emergency Operations Manager

c. At St. Louis District:

(1) Bruce Moore, Chief, F & M Branch

(2) George Postol, Chief, Soils Section

(3) Tom Wolff, Engineer, F & M Branch

(4) Benidict F. Venturella, Natural Emergency Program Coordinator

d. At Rock Island District:

(1) George Mech, Chief, Geotechnical Branch

(2) Vernon H. Greenwood, Natural Emergency Manager

(3) Gene Wassenhove, Operations Division Inspection Enforcement

(4) Don Bawmann, Technician, Geotechnical Branch

(5) Sibte Zaidi, Engineer, Geotechnical Branch

(6) Dave Borck, Technician, General Engineering Section, Design Branch

(7) Ken Jensen, Retired, Formerly Chief, Geotechnical Branch

APPENDIX B: DOCUMENTS COLLECTED FROM CE DISTRICT OFFICES

1. The documents relating to underseepage that were collected during the visits to the Vicksburg, Memphis, St. Louis, and Rock Island CE Districts are listed below:

a. From Vicksburg District:

(1) Natural Disaster Response, Emergency Employment of Army and other Resources, Natural Disaster Activities under PL 84-99 and PL 93-288, LMK SOP 500-1, September 1982.

(2) LMK SOP 500-1, Change 1, 31 December 1984.

(3) Vicksburg District Supplement A to ER 500-1-1, Natural Disaster Procedures, Emergency Flood Control under PL 84-99, LMKEM DF, 24 July 1981.

(4) Flood Emergency Handbook for Local Officials, US Army Engineer District, Vicksburg, January 1984.

(5) Flood Emergency Handbook, Standard Operative Procedures, US Army Engineer District, Vicksburg, July 1984.

(6) DAEN-CWO-E, Emergency Management Key Personnel List, 9 September 1983.

(7) Emergency Operation: Mud Box Demonstration, LMKOD-O DF, 25 March 1982.

b. From Memphis District:

(1) Emergency Employment of Army and other Resources, Natural Disaster Assistance Primarily under PL 84-99 and PL 92-228, MDR 500-1-1, November 1984.

(2) List of Local Flood Control Districts and Officials, Memphis District, January 1985.

(3) Emergency Flood Control Activities, Annex O to MDR 500-1-1, August 1984.

c. From St. Louis District:

(1) Natural Disaster Procedures, Emergency Employment of Army and Other Resources, ER 500-1-1, 21 December 1983.

(2) Natural Disaster Response Plans, Emergency Employment of Army and other Resources, Natural Disaster Activities under PL 84-99 and PL 93-288, St. Louis District, DR 500-1-1, -2, -3, -4, -5, -6, 1 April 1985.

(3) Flood Manual, Emergency Organization and Operations, Foundation and Materials Branch (St. Louis District), update 1979.

(4) Re-evaluation of Underseepage Controls Mississippi River Levees, Seton to Gear, IL, Phase I: Performance of Underseepage Controls During the 1973 Flood, Vol I: Text, US Army Engineer District, St. Louis, Missouri, June 1976.

d. From Rock Island District:

(1) Natural Disaster Procedures, Rock Island District, 31 January 1985.

(2) Handbook for Emergency Flood Protection, Rock Island District, undated.

(3) Dam Safety Training for Operations and Maintenance Personnel, Rock Island District, undated.

(4) Continuing Authorities Program, Rock Island District, undated.

(5) Natural Emergency Handbook, EP 500-1-1, 28 October 1976.

(6) Emergency Operations, US Army Corps of Engineers, EP 500-1-3, July 1982.

(7) Streambank Protection for Land Owners and Local Governments, US Army Corps of Engineers, flyer, undated.

(8) Streambank Protection Guidelines for Landowners and Local Governments, US Army Corps of Engineers, October 1983.

APPENDIX C: QUESTIONS RELATED TO INSPECTIONS FOR UNDERSEEPAGE DURING FLOODS

1. During the visits to the Vicksburg, Memphis, St. Louis, and Rock Island CE Districts, many questions (prepared in advance) were asked concerning the inspections made for underseepage. The organization, office, and related questions are presented below:

a. General information about District:

(1) What is size of District, square miles?

(2) How many miles of mainline levee are in District?

(3) Approximate total personnel strength of District?

(4) Approximate total personnel in field offices (Area Engineer Offices)?

(5) Approximate total personnel in F & M Branch?

(6) What percentage of personnel from the District, Field, and F & M Branch gets involved in inspection for underseepage during floods?

(7) What is responsibility of the Corps?

b. Levee Board Activities:

(1) What is responsibility of Levee Board with respect to underseepage inspection?

(2) Who are on the Levee Board?

(3) Who appoints or how are Levee Board members determined?

(4) At what river stage are regular flood related inspections started?

(5) What is frequency of inspection?

(6) When and to whom are reports submitted?

(7) At what river stage are emergency inspections made? Frequency of inspection? Reports? Written reports?

(8) How many inspection teams are used during a flood?

(9) Who establishes makeup of inspection team?

(10) Who and how many are on inspection team?

(11) How are inspections made?

(12) What instructions do inspectors get?

(13) How is information on past trouble spots passed on to new inspectors?

(14) Are inspectors given training?

(15) Is written guidance available for evaluation of underseepage?

(16) Is underseepage classified by degree of severity?

(17) What terminology is used to describe underseepage?

(18) Based on observed distress, who makes assessment of potential for levee damage or destruction?

(19) Who decides what is to be done about underseepage problem for the emergency period?

(20) Who does the work?

(21) Who pays for the work?

(22) Who provides right of way to trouble area?

(23) What is responsibility of local landowner?

(24) From where does Levee Board get its funds?

(25) What is responsibility of City? County? State?

(26) What written guidance is available for selection of method for control of underseepage?

(27) What innovative measures have been tried for control of underseepage?

c. Area Engineer Office Activities for Underseepage Inspection:

(1) What is responsibility of Area Engineer for underseepage inspection?

(2) At what river stage are regular flood related inspections started?

(3) What is frequency of inspection?

(4) When and to whom are reports submitted?

(5) At what river stage are emergency inspections made? Frequency of inspection? Reports? Written reports?

(6) How many inspection teams are used during a flood?

(7) Who establishes makeup of inspection team?

(8) Who and how many are on inspection team?

(9) How are inspections made?

(10) What instructions do inspectors get?

(11) How is information on past trouble spots passed on to new inspectors?

(12) Are inspectors given training?

(13) Is written guidance available for evaluation of underseepage?

(14) Is underseepage classified by degree of severity?

(15) What terminology is used to describe underseepage?

(16) Based on observed distress, who makes assessment of potential for levee damage or destruction?

(17) Who decides what is to be done about underseepage problem for the emergency period?

(18) Who does the work?

(19) Who pays for the work?

(20) What written guidance is available for selection of method for control of underseepage?

(21) What innovative measures have been tried for control of underseepage?

(22) Who recommends permanent remedial action?

d. F & M Branch activities related to inspection and control of underseepage:

(1) What is responsibility of F & M Branch with regard to underseepage inspection?

(2) At what river stage will F & M Branch personnel make underseepage inspection?

(3) What is frequency of inspection?

(4) When and to whom are reports submitted?

(5) At what river stage are emergency inspections made? Frequency of inspection? Reports? Written reports?

(6) How many inspection teams are used during a flood?

(7) Who establishes make up of inspection team?

(8) Who and how many are on inspection team?

(9) How are inspections made?

(10) What instructions do inspectors get?

(11) How is information on past trouble spots passed on to new inspectors?

(12) Are inspectors given training?

(13) Is written guidance available for evaluation of underseepage?

(14) Is underseepage classified by degree of severity?

(15) What terminology is used to describe underseepage?

(16) Based on observed distress, who makes assessment of potential for levee damage or destruction?

(17) Who decides what is to be done about underseepage problem for the emergency period?

(18) Who does the work?

(19) Who pays for the work?

(20) Who recommends permanent remedial action?

(21) Who decides what permanent works will be built?

(22) From where does the money come for permanent works?

(23) Who establishes priorities for permanent construction?